Space Weather Technical Forecast

Issued on Wednesday, 21 December 2022 at 13:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of M-class flares and G1/Minor Geomagnetic Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with an M1.1 flare peaking at 20/1408 UTC from AR3169 (Csi/Beta-Gamma), which has produced the majority of activity during the period. There have also been frequent C-class flares, with next largest flare a C7.6 at 21/0622 UTC from AR3166 (Dso/Beta). There are currently seven sunspots on the disc. AR3169 is an elongated group with a series of relatively small leader spots, but no penumbra now on the trailer spots. There is some magnetic complexity, especially due to its proximity to the smaller following region AR3171 (Csi/Beta-Gamma), which also has some magnetic complexity. The split between these two regions is difficult to determine. AR3170 in the southeast has also had some C-flare activity during the period, but is now starting to fade. The largest region, AR3163 (Dki/Beta), has a large leader spot with nearby reverse polarity spot emergence, but has seen fading of its trailing spots and it remains inactive so far. AR3163 and A3166 are now approaching the southwest limb. The other regions on the disc are generally smaller and stable.
A filament lifted off from the northwest around 20/2000 UTC and an eruption occurred near AR3169 associated with a C6.3 flare at 21/0519 UTC. Both these events are considered not to be Earth directed and thus no Earth-directed CMEs were observed in the period, but further analysis is ongoing.

Solar Wind / Geomagnetic Activity: Solar winds have been indicative of one or perhaps two weak transient features passing Earth, likely due to glances from a CME, potentially coupled with a weak enhancement from CH54/-. Solar wind speeds remained at background levels, around 350-400 km/s. Density has generally been average, with a peak slightly above average of 13 ppcc at 20/1306 UTC. The total IMF, Bt, was mostly Moderate peaking at 15nT around 21/0830 UTC. The Bz oscillated between southward and northward, varying between +10 and -11 nT. The phi angle was mainly negative (towards the Sun), but with some variations to positive early in the period. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background levels. The associated 24-hour fluence was on a steady trend well below Active (1e8 integrated pfu). Observed fluence at 21/0001 UTC was 1.37e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with occasional C-flares and an ongoing chance of isolated M-flares. The most likely source is either AR3163 in the southwest, or AR3169 and AR3171 in the northeast. These also bring a very slight chance of X-class flares.

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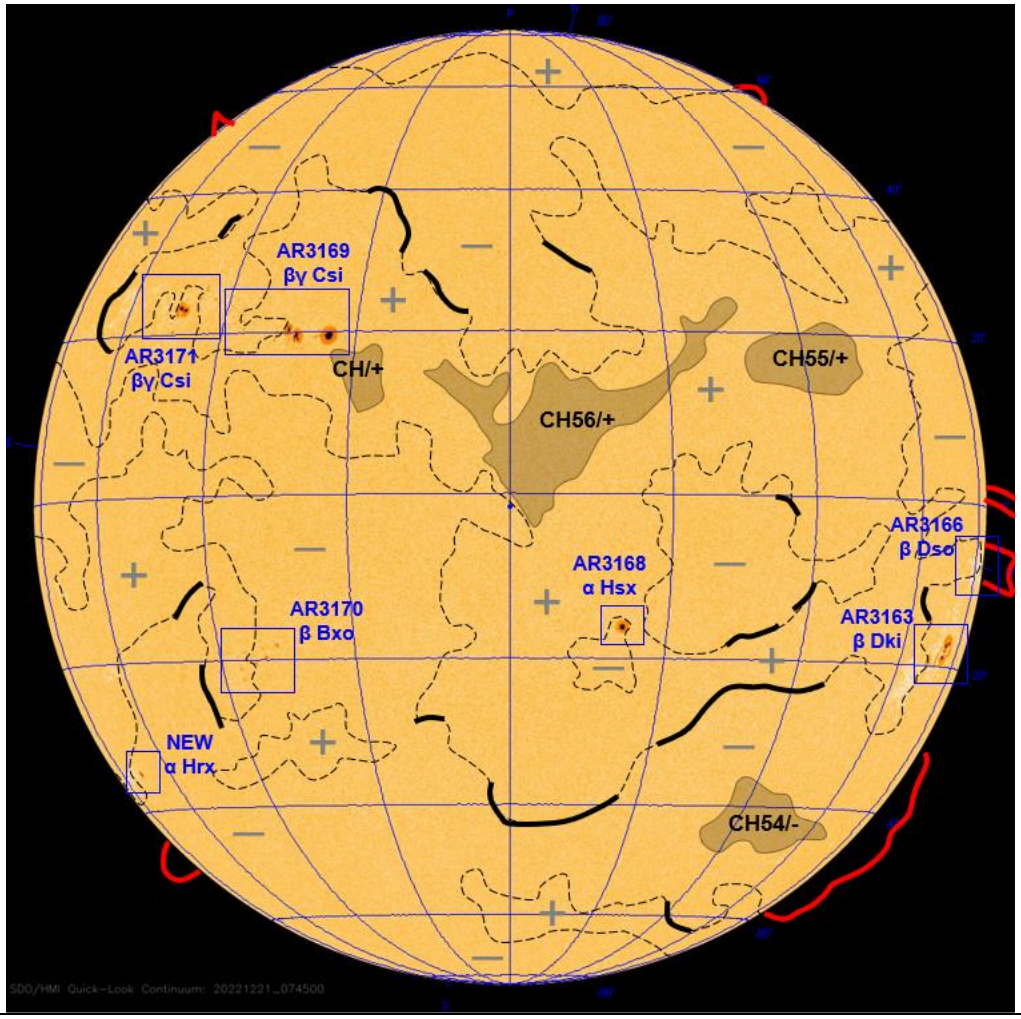
Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs expected. Solar winds are forecast to become elevated later on Day 1 or early Day 2 (21-22 Dec) due to the arrival of the High Speed Stream (HSS) of CH55/+. Ongoing fast winds are then expected with a succession of coronal holes moving from CH55/+ to CH56/+. Wind speeds are likely to remain at slightly elevated or elevated levels for the rest of this period.
Quiet to Unsettled geomagnetic activity at first, is expected to become Unsettled to Active later on Day 1 or early Day 2, with a chance of isolated G1/Minor Storm intervals. This chance decreases a little into Day 3 (23 Dec), before increasing slightly again on Day 4 (24 Dec) as CH56 is likely to become geoeffective.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, although there is slight chance of this reaching the S1/Minor Storm level should any notable flares occur. High energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background levels. An increase is possible later in the period due to expected fast winds arriving on Days 1 or 2 (21-22 Dec). The associated 24 hour electron fluence is forecast to remain below the Active (1e8 integrated pfu) threshold, perhaps with a slight rise towards the end of the period.

Figure 1. Solar Analysis Valid 21/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

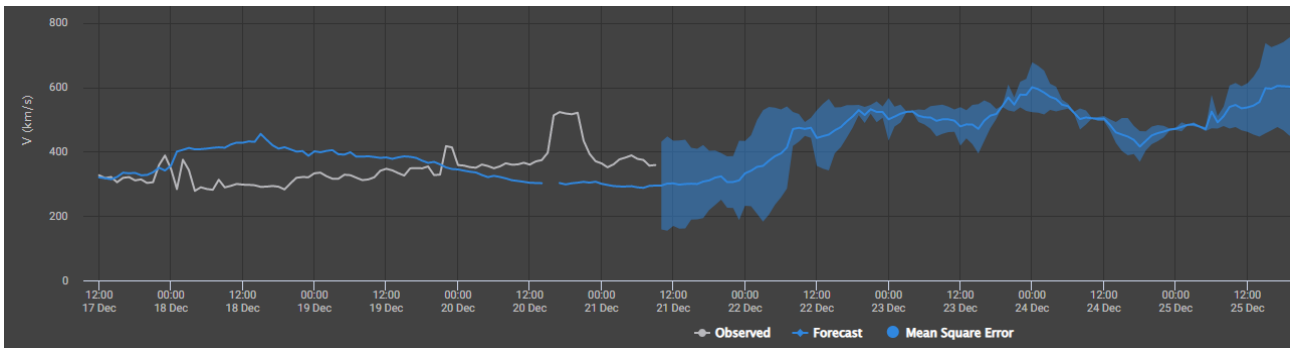
There are no Earth-directed CMEs expected, but weak CME effects cannot be completely ruled out with a couple of recent centre disc eruptions, although these are most likely to have been reabsorbed.
Solar winds are forecast to become elevated later on Day 1 or early Day 2 (21-22 Dec) due to the arrival of the High Speed Stream (HSS) of CH55/+. This is in agreement with MOSWOC Enlil and the 27-day persistence model. Confidence is starting to increase in the strength and timing of this onset, as STEREO-A data has now detected a rotation to a positive phi angle with a gradual increase in density followed by an increase in wind speeds. STEREO-A is just over a day ahead of Earth with respect to the Parker Spiral so an enhancement in the next 24 hours seems likely. Ongoing fast winds are then expected with a succession of coronal holes moving from CH55/+ to CH56/+. Whilst there may be slight wind speed decreases in between the main HSS of each coronal hole, wind speeds are likely to remain at slightly elevated or elevated levels for the rest of this period.
Quiet geomagnetic activity at first, is expected to become Unsettled to Active later on Day 1 or early Day 2, with a chance of isolated G1/Minor Storm intervals. This chance decreases a little into Day 3 (23 Dec), before increasing slightly on Day 4 (24 Dec) as CH56 is likely to become geoeffective.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	30	20	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil

Figure 2: MOSWOC Solar Wind Persistence Model



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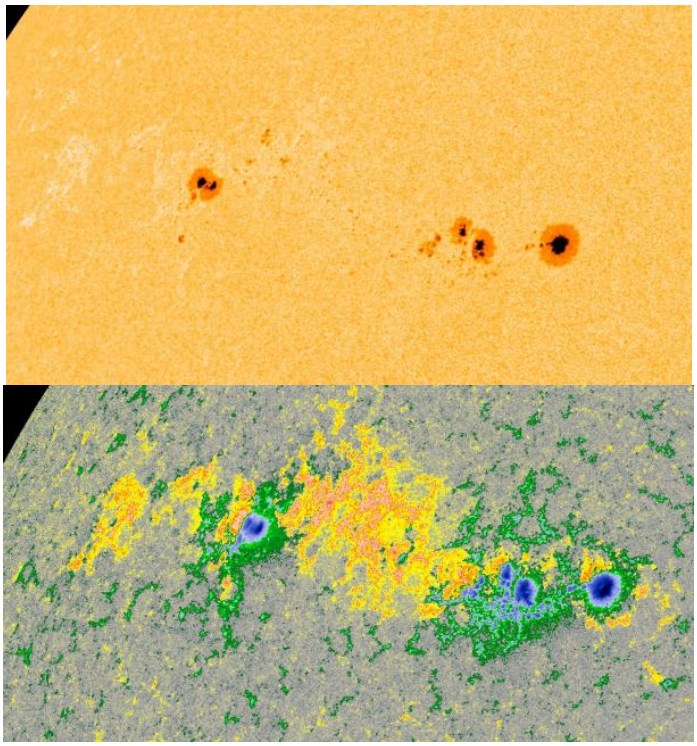
Radio Blackouts - X-Ray Flares:

There are seven sunspot regions on the visible disc, with activity forecast to be Low to Moderate. There is a chance of M-flares, with a very slight chance of X-class flares.
AR3169 (Csi/Beta-Gamma) is currently the most active region on the disc, as an elongated group consisting of a number of mature leader spots but with no penumbra on the trailing spots. It has some magnetic complexity, but this is complicated by its proximity to AR3171 (Csi/Beta-gamma), which also has some magnetic complexity. The split between these two regions is difficult to determine, however. The largest region on the disc is AR3163 (Dki/Beta). This region is approaching the southwest limb, but has seen development of its leading spot with a reverse polarity spot only just behind the large leading spot. The other regions are generally smaller and simpler, however far-side products suggest further regions are likely to rotate onto the disc though the period. As such, although some regions are due to rotate off in this period, with others likely to rotate on, the flare risk has been kept consistent throughout.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: SDO intensitygram and magnetogram of AR3169 and AR3171.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is expected to remain at background levels. However, through the period there is a slight chance of an enhancement reaching the S1 Minor Storm level, with a number of notable sunspots currently on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background levels. Fast wind arrival either later on Day 1 or early on Day 2 (21-22 Dec) has the potential to result in increased counts later in the period, most likely rising to Moderate, with a chance of a diurnal peak of High on Days 3 and 4 (23-24 Dec). Some uncertainty is introduced by the fact that fast winds are likely to be ongoing for several days, so confidence in the timing and magnitude of any rise is only moderate at best.
The associated 24 hour electron fluence is forecast to remain below the Active (1e8 integrated pfu) threshold, as indicated by REFM, which is currently giving good guidance. On the previous rotation which was similar in terms of coronal holes, the fluence rose on the equivalent of Day 4 but didn't quite reach Active for several more days. As such, fluence may rise later in the period, however this is low confidence and it is more likely fluence will stay below Active until next week.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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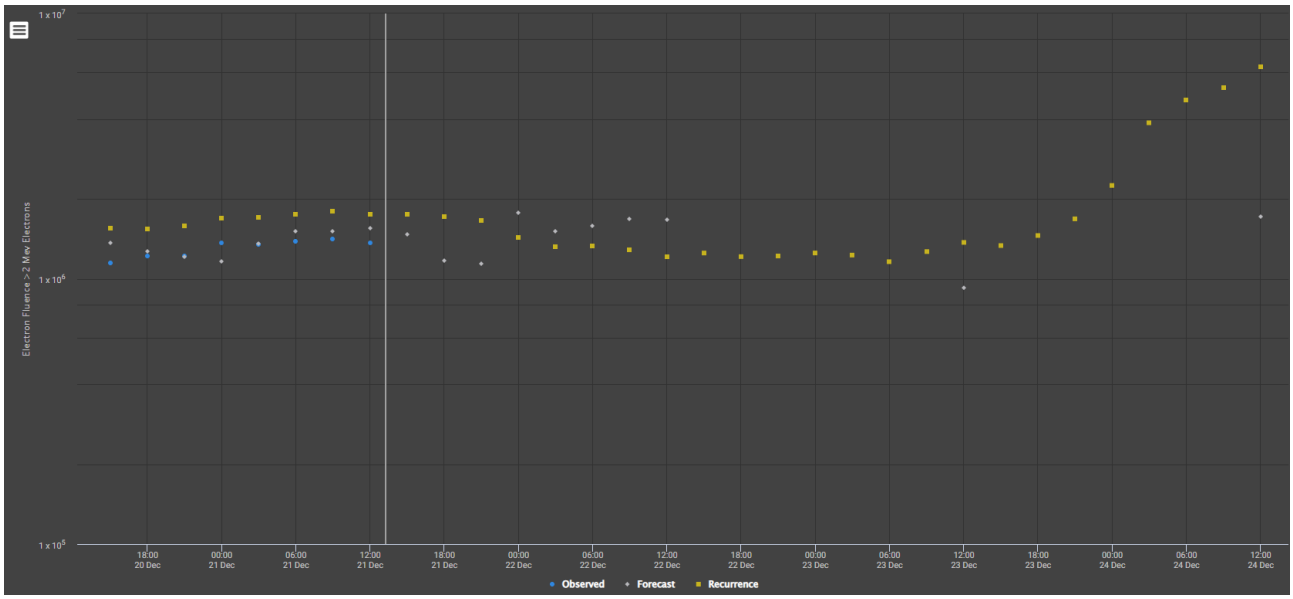
Figure 4: GOES 16 observed electron fluence, REFM data and recurrence, showing increase day 4.



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